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LOW-YIELD NUCLEAR EXPLOSION CALCULATIONS:
THE 9/22/79 VELA SIGNAL (U)

by

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ABSTRACT (SRD)

Normally, independent confirming evidence is available from other VELA satellites and other sources. Unfortunately, such confirming evidence has not been uncovered for the 9/22/79 event.

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In this report we summarize the vela data, discuss classical interpretations, and present a particular model which, we believe, satisfactorily reproduces the Vela signal.

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Thus, our model is consistent with the apparent absence of nuclear debris, the collection of which is required by some analysts for absolute confirmation of an atmospheric detonation.

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I. THE VELA DATA

The VELA satellite and its detectors are described elsewhere (e.g. Horak 1980). For our purposes, the salient features of the detections system are

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observed by the VELA satellite. As a first step, we use classic scaling laws to estimate the significant parameters of yield and burst height density; then we discuss computer calculations chosen to provide more precise estimates of the explosion parameters.

Numerous sets of scaling laws exist. Here, we have synthesized four adequate scaling laws from discussions by Zinn et al. (1974) and Sappenfield (1979).

As we shall see, the time of first maximum and the power ratios are inconsistent with the other observations. Solving the puzzle will concern most of the rest of our study.

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Clearly, conventional scaling laws cannot provide a consistent model for the VELA data.

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The values of the observable quantities (t_{1-max} , t_{2-max} , and $P_{2-max}P_{min}$) have large uncertainties.

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Both Y and p are model independent because they are the basic parameters of any calculation. The other three factors can vary dramatically among different models. Let us now consider these other factors and discuss how they can affect the signal.

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significant modification of the signal by the atmosphere or by clouds.

Nuclear weapons with significant neutron output can create an obscuring curtain of "smog" (principally NO₂, HNO₂, and O₃). As discussed by Zinn et al. (1974), smog may produce not only a delay in first maximum but also a severe depression of the first pulse by absorption. The minimum and second maximum usually are unaffected by smog because the fireball radius at these times exceeds the distances at which significant neutron deposition occurs.

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Perhaps the most dramatic mass effect has been known since the earliest days of atmospheric testing: the *apparent yield* of a burst at the earth's surface (land or sea) is twice the actual yield. The reason is simply that the surface acts as a nearly perfect reflecting plane. The entire explosion energy acts only in the hemisphere above the surface as if the surface were absent and we were witnessing the spherical expansion of a higher yield explosion. The result is that the radiative/hydrodynamic behavior is identical to that of a free-air burst at twice the actual yield. Among others, Sappenfield (1979) has reviewed the empirical evidence supporting this result.

Cloud cover, atmospheric absorption, and scattering by particulates between the explosion and the satellite can alter the interpretation of the signal. Atmospheric transmission must be considered when deriving radiance at the source from the observed irradiance. However, simple absorption by the atmosphere will not produce dramatic shifts in the timings of events in the signal nor, to first order, will it depress one part of the signal relative to another. However, cloud cover can introduce time smearing caused by photon scattering. Multiple photon scatterings can delay first maximum but should also depress the signal in both peaks. The observed irradiance levels are high enough that the signal could not have suffered much absorption nor scattering beyond that expected for relatively clear maritime air. We do not believe that the data supports the contention that there was any

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The hydrodynamic behavior and the power-time curve of this case are illustrated in Figs. 3 and 4, respectively.

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The rest of this report discusses the effects of mass on the complete optical signal.

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III. RADFLO CALCULATIONS

What matters here is the kinetic energy content of the debris, which is largely insensitive to the material composition.

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For our present purposes, we have chosen to do calculations in which the nuclear explosive is modeled as a sphere of high-density air at uniform density. The "air bomb" comprises the 10 innermost cells in the calculational grid.

The principal results are tabulated in Tables II and III.

The effect of M and ρ on the times of minimum and of the two maximums are shown in Figs. 7-9. The choice of a time value from a calculation or from data is subjective.

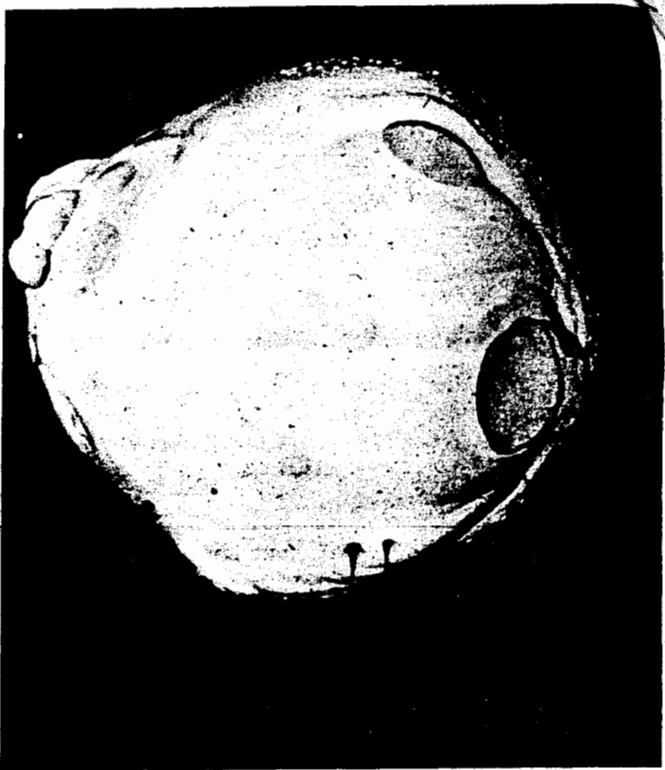
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In each calculation, a certain fraction of the explosion energy is deposited as internal energy at $t = 0$ in the central cell.

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GEORGE was detonated atop a tower 61 m above Eniwetok on May 9, 1951.

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Two features in the explosion phenomenology are of interest. First, the fireball expansion was very asymmetric during the early phases; second, independent determination of the yield by hydrodynamic and radiochemical techniques were widely discrepant.

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The other part of the fireball may have grown radiatively. Clearly, calculational studies in two or three dimensions will be required to provide a convincing explanation.

At later times, the expansion becomes more symmetric and, at minimum, this fireball has prominent spots.

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The hydrodynamic yield is determined by comparing the radius-time data with the expectations of classic blast wave theory. In particular, during the period immediately preceding minimum, the quality

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is virtually constant. In Fig. 16, we show the ϕ histories obtained from four RADFLO calculations compared

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VI. CAVEATS

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with the GEORGE data. These data were derived by visually estimating a "best-circle" fit to the fireball shape.

Nonetheless, we recognize that we have made certain assumptions that, if proved wrong, may alter our conclusions.

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(2) We have used dense air to model the weapon vapor.

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We have been unable to secure experimental confirmation of a t_{1-max} delay caused by mass.

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*Private communication to authors.



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